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(54) Hydraulic control valve assembly

(57) A hydraulic control valve assembly 10, for use in a mineral mining installation, comprises a housing 10a containing a pressure-relief valve 11, 13 and a hydraulically-operated actuator 17, 24 therefor. The housing has an inlet 14 connectible to a hydraulic consumer, and an outlet connectible to a hydraulic return line 16. The valve has a seat 13 and a spring-biased ball 11, and is positioned in the fluid flow path between the inlet 14 and the outlet. The actuator is constituted by a piston 17, a push rod 24, and a control chamber 22 connectible to a hydraulic control line 23. The push rod 24 is displaceable to move the ball 11 from the valve seat 13. Pressure surges which may occur in the control line 23, when it is connected to a return line, are inhibited from opening the valve 11, 13 by valve means 29. Alternatively, both sides of the piston are exposed to the return line pressure when the valve is closed.

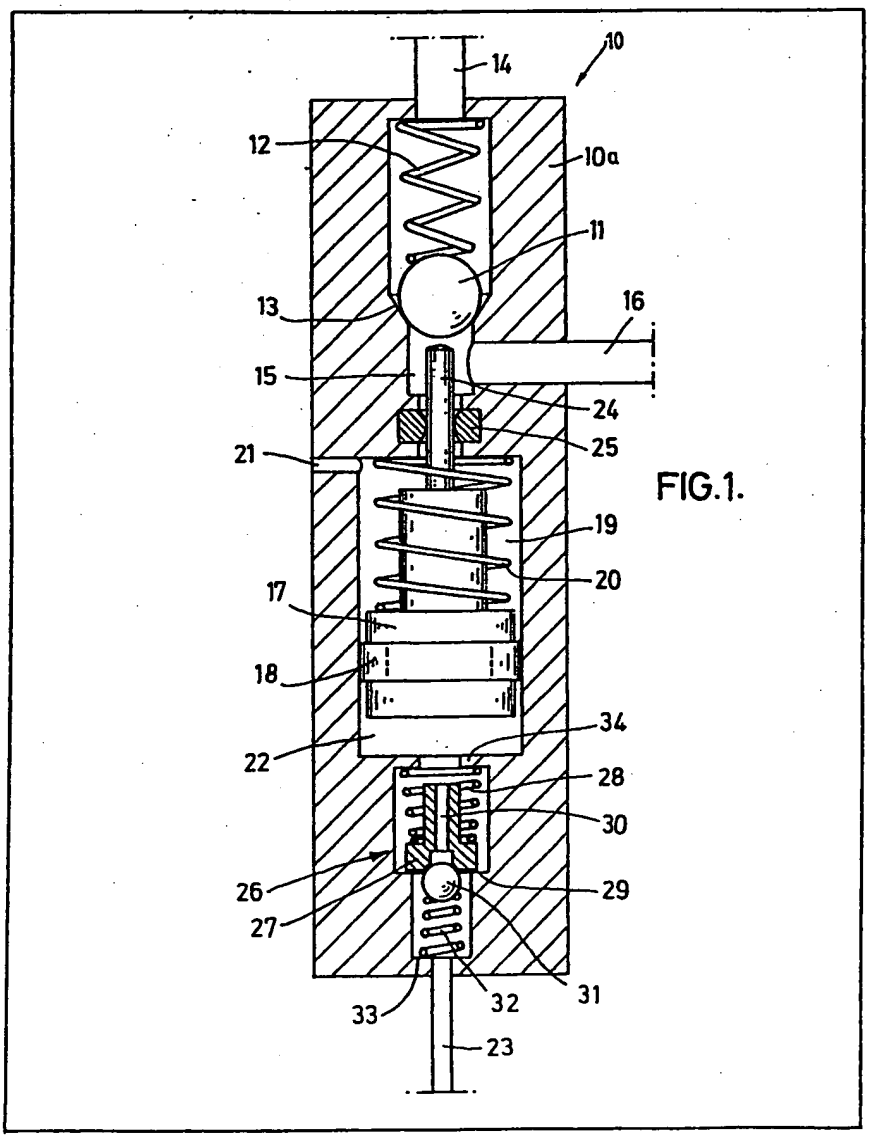

FIG.1.

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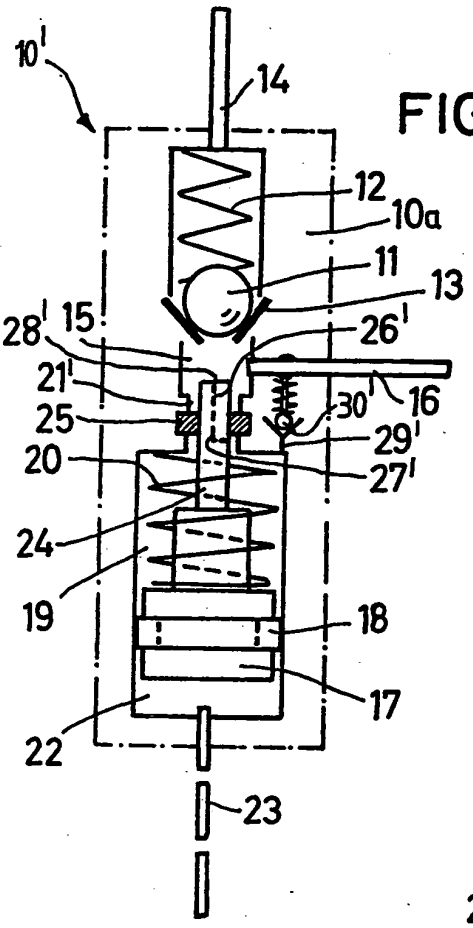
10'
14
12
10a
11
13
28'
15
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16
29'
20
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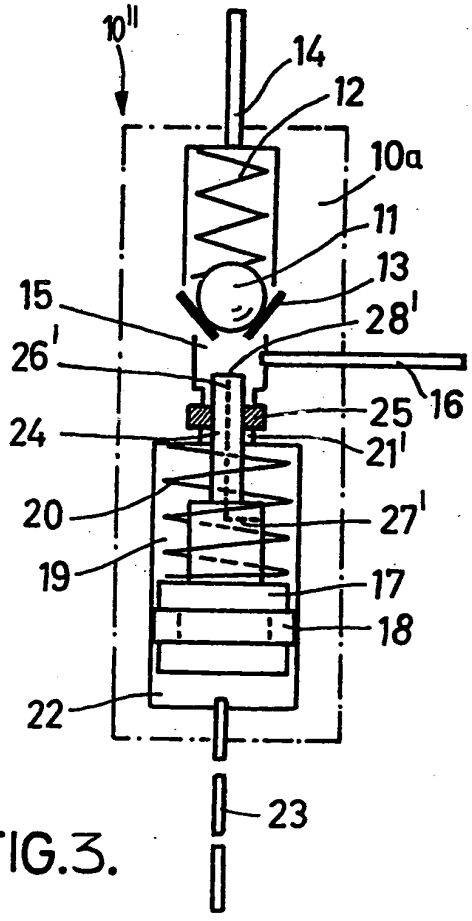
19
18
17
22
23

FIG.2.


10''
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23

FIG.3.

Advantageously, the subsidiary pressure-relief valve is positioned in an axial bore formed within the housing. Preferably, the subsidiary pressure-relief valve is provided with an auxiliary pressure-relief valve, the auxiliary pressure-relief valve being arranged to open, thereby permitting hydraulic fluid to flow from the control chamber to the control line, when the piston moves so as to decrease the volume of the control chamber.

In another preferred embodiment, when the pressure-relief valve is closed, the spring chamber is connected to the valve chamber by means of a passage provided in the push rod, and, when the pressure-relief valve is open, the connection between the spring chamber and the valve chamber via said passage is closed, said passage constituting the inhibiting means. In this case, any pressure surges arising from back pressures in the return line are applied to both sides of the piston. Thus, the piston is pressure-equilibrated, so that unintentional operation of the pressure-relief valve is prevented.

Advantageously, the push rod passage is constituted by an axial bore and a transverse bore, the axial bore opening into the valve chamber at the end face thereof remote from the piston, and the transverse bore being positioned so as to open into the spring chamber when the pressure-relief valve is closed. The transverse bore may be so positioned that, when the pressure-relief valve is open, the transverse bore opens into the valve chamber. Alternatively, the transverse bore is so positioned that, when the pressure-relief valve is open, the transverse bore opens into the spring chamber. In either case, the valve chamber and the spring chamber may be connected by a longitudinal bore formed in the housing, and wherein a further pressure-relief valve is positioned within said longitudinal bore, the further pressure-relief valve being arranged to open only during the movement of the piston which results in the opening of the pressure-relief valve.

It is also possible for the push road seal to be adapted to constitute a suction valve which connects the valve chamber with the spring chamber when the push rod moves away from the pressure-relief valve.

Three forms of hydraulic control valve assembly, each of which is constructed in accordance with the invention, will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a part-sectional side elevation of the first form of valve assembly;

Fig. 2 is a schematic sectional view of the second form of valve assembly; and

Fig. 3 is a schematic sectional view of the third form of valve assembly.

Referring to the drawings, Fig. 1 shows a hydraulic control valve assembly 10 having a housing 10*a* formed with an internal longitudinal bore. This bore has a plurality of steps for accommodating the different operational parts of the valve assembly 10.

The hydraulic control valve assembly 10 includes a pressure-relief (non-return) ball valve having a ball 11, a spring 12 and a valve seat 13. The ball 11 constitutes the closure member of the valve, and is biased towards its closed position on the valve seat 13 by the spring 12. That part of the stepped bore which accommodates the spring 12 defines a high-pressure working chamber. The high-pressure chamber is connected, via a high-pressure line 14, to the working chamber(s) of the hydraulic consumer(s) to be controlled by the valve assembly 10. For example, the line 14 could be connected to the working chambers of one or more of the hydraulic props of a mine roof support unit. That part of the stepped bore on the opposite side of the valve seat 13 to the spring 12 defines a valve chamber 15. The valve chamber 15 is connected to a return line 16 via a radial passage formed in the housing 10*a*.

An actuator piston 17 is reciprocable within that part of the stepped bore on the opposite side of the valve chamber 15 to the valve seat 13. The actuator piston 17 is of stepped construction, and its maximum diameter portion if provided with a piston ring seal 18 which seals the actuator piston against the cylindrical wall of that part of the stepped bore which accommodates it. A spring 20 is accommodated within a spring chamber 19 which is defined by that part of the stepped bore positioned between the piston 17 and the valve chamber 15. The spring 20 biases the actuator piston 17 away from the valve chamber 15. The spring chamber 19 communicates with the atmosphere via a bore 21. That part of the stepped bore on the opposite side of the actuator piston 17 to the spring chamber 19 defines a control chamber 22. The control chamber 22 is connected to a hydraulic control line 23, which control line is positioned at the opposite end of the housing 10*a* to the high-pressure line 14.

The actuator piston 17 is provided with a push rod 24 which extends axially towards the valve seat 13. A push rod seal 25 is provided to seal the valve chamber 15 from the spring chamber 19.

A control valve 26 is provided to control the supply of pressurised hydraulic fluid to the control chamber 22. The control valve 26 is a pressure-relief valve having a closure member 27 which is biased towards a valve seat 29 by means of a spring 28. The valve seat 29 is constituted by an annular shoulder in the stepped bore within the housing 10*a*. An axial through bore 30 is formed in the closure member 27. The bore 30 is normally closed by a small valve ball 31 which is held against a valve seat provided on the closure member 27 by means of a weak spring 32. The bore 30, the ball 31, the spring 32 and the valve seat provided on the closure member 27 thus define an auxiliary pressure-relief valve. The spring 32 bears against the end 33 of the stepped bore; whilst the stronger spring 28, which acts in the opposite direction, bears against an annular shoulder 34 defined by the stepped bore.

In practice the valve assembly 10 is used with a plurality of identical valve assemblies to control a

In use, the valve assembly 10′ of the Fig. 2 embodiment is incorporated (together with identical valve assemblies) in an arrangement similar to that described above with reference to Fig. 1. In order to open a given valve assembly 10′, its control chamber 22 is charged with pressurised hydraulic fluid via the control line 23. This causes the actuator piston 17 to be displaced, against the force of its spring 20, towards the pressure-relief valve 11, 13. During this movement, the excess hydraulic fluid in the spring chamber 19 is forced through the auxiliary pressure-relief valve 30′ and into the return line 16. During the working stroke of the actuator piston 17, the transverse bore 27′ passes from the spring chamber 19 and across the push rod seal 25 into the valve chamber 15. At the same time, the end face 28′ of the push rod 24 lifts the ball 11 away from its valve seat 13 against the force of the spring 12. Thus, the pressure-relief valve 11, 13 is opened to connect the associated hydraulic consumer with the return line 16, via the line 14, the open valve 11, 13 and the valve chamber 15. Pressure can build up in the valve chamber 15, since the cross-section of the radial passage leading to the return line 16 is not large enough to accommodate the sudden surge of hydraulic fluid which occurs as the valve 11, 13 is opened. Since the transverse bore 27′ now opens into the valve chamber 15, this chamber is no longer connected to the spring chamber 19. Thus, any pressure built up in the valve chamber 15 on opening the pressure-relief valve 11, 13 cannot be transmitted to the spring chamber 19 and so there is no pressure build-up in the spring chamber 19 which would tend to return the actuator piston 17 to its initial position. Consequently, so-called relaxation surges are avoided, so that valve vibration and the generation of noise are prevented.

If the pressure-relief valve 11, 13 is to be closed, the control line 23 is connected to the return line 16. This leads to the pressure in the control chamber 22 falling, and hence to the actuator piston 17 returning to its initial position under the action of the spring 20. As soon as the transverse bore 27′ in the push rod 24 opens into the spring chamber 19, hydraulic fluid is sucked out of the valve chamber 15 into the spring chamber 19.

The valve assembly 10′ accommodates back pressures in the return line 16 in a different way from that described above with reference to Fig. 1. Thus, the back pressures that occur in the return line 16 act, via the control line 23, on the circular end face of the actuator piston 17; and, at the same time, these back pressures act, via the valve chamber 15, the bores 26′ and 27′ and the spring chamber 19, on the other (annular) end face of the actuator piston. Consequently, the actuator piston 17 is pressure-equilibrated, so that the valve assembly 10′ is not unintentionally actuated.

The valve assembly 10′ could be modified by replacing the push rod seal 25 with the known type of push rod seal. During the return movement of the actuator piston 17, such a seal acts as a non-return valve, that is to say it opens a fluid flow path between the valve chamber 15 and the spring chamber 19, the fluid flow path passing along the circumference of the push rod 24. When the pressure-relief valve 11, 13 is in the closed position, and when the pressure-relief valve 11, 13 is fully open, the push rod seal reliably seals off the spring chamber 19 from the valve chamber 15. Obviously, in this case, the push rod 24 would not be provided with the bores 26′ and 27′.

Fig. 3 shows a modified version of the assembly 10′ of Fig. 2. The assembly 10″ of Fig. 3 is very similar to the assembly 10′, and so like reference numbers have been used for like parts. The essential difference between the two assemblies 10′ and 10″ is that the assembly 10″ has no auxiliary pressure-relief valve 30′. Instead, the axial bore 26′ in the push rod 24 is extended so far back towards the actuator piston 17 that the transverse bore 27′ opens into the spring chamber 19 even when the push rod has been fully extended to open the pressure-relief valve 11, 13. Thus, as with the embodiment of Fig. 2, any back pressures in the return line 16 are transmitted to both sides of the actuator piston 17 (one side being affected via the control line 23 and the control chamber 22, and the other side being affected via the valve chamber 15, the bores 26′ and 27′ and the spring chamber 19). Consequently, the actuator piston 17 is pressure equilibrated, so that the valve assembly 10″ is not unintentionally actuated.

In order to open the valve assembly 10″, the control chamber 22 is charged with pressurised hydraulic fluid via the control line 23. This causes the actuator piston 17 to be displaced, against the force of the spring 20, until its push rod 24 lifts the ball 11 away from its valve seat 13. During this movement of the actuator piston 17, the excess hydraulic fluid in the spring chamber 19 is forced through the bores 26′ and 27′ and into the return line 16 via the valve chamber 15. The ball 11 covers the mouth of the bore 26′ in the end face 28′ of the push rod 24. Thus, when the pressure-relief valve 11, 13 is open, the fluid flow path between the valve chamber 15 and the spring chamber 19 is blocked. Consequently, any pressure built up in the valve chamber 15 on opening the pressure-relief valve 11, 13 cannot be transmitted to the spring chamber 19; and so there is no pressure build-up in the spring chamber which would tend to return the actuator piston 17 to its initial position. Hence, relaxation surges are avoided.

If the pressure-relief valve 11, 13 is to be closed, the control line 23 is connected to the return line 16. This leads to the pressure in the control chamber 22 falling, and hence to the actuator piston 17 returning to its initial position under the action of the spring 20. During this movement, as soon as the ball 11 is disengaged from the mouth of the bore 26′ in the end face 28′ of the push rod 24, hydraulic fluid is sucked out of